

Problems in Minimum Ignition Energy Determination

Dr. Martin J. Rabinowitz

Research and Technology Directorate
NASA Glenn Research Center
Brookpark, Ohio 44122

Collaborators:

Robert R. Bickford, Gregory S. Calhoun, Christopher L. Hegedus,
Bryan E. Knepper, Yves C. Lamothe, James E. Sexton



This Seems Well Understood

Well, not really.

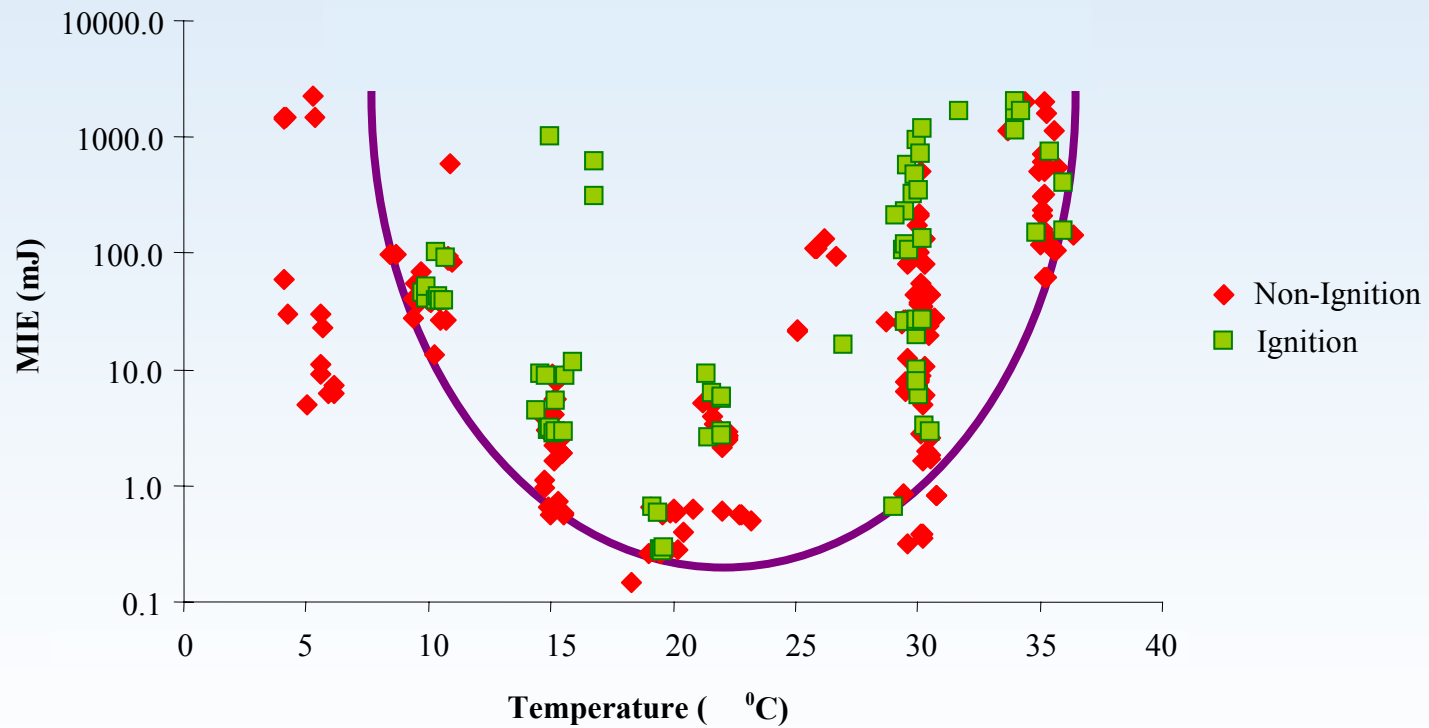
The determination of minimum ignition energy curves for fuel/air mixtures have been problematical with widely varying results for different groups using different fuels, fuel treatment regimes and ignition sources.

The focus of attention on the root cause of the variations has been in the fuel and fuel treatment. While there is considerable variation in refinery products and handling such variations are also observed for chemically pure fuels.

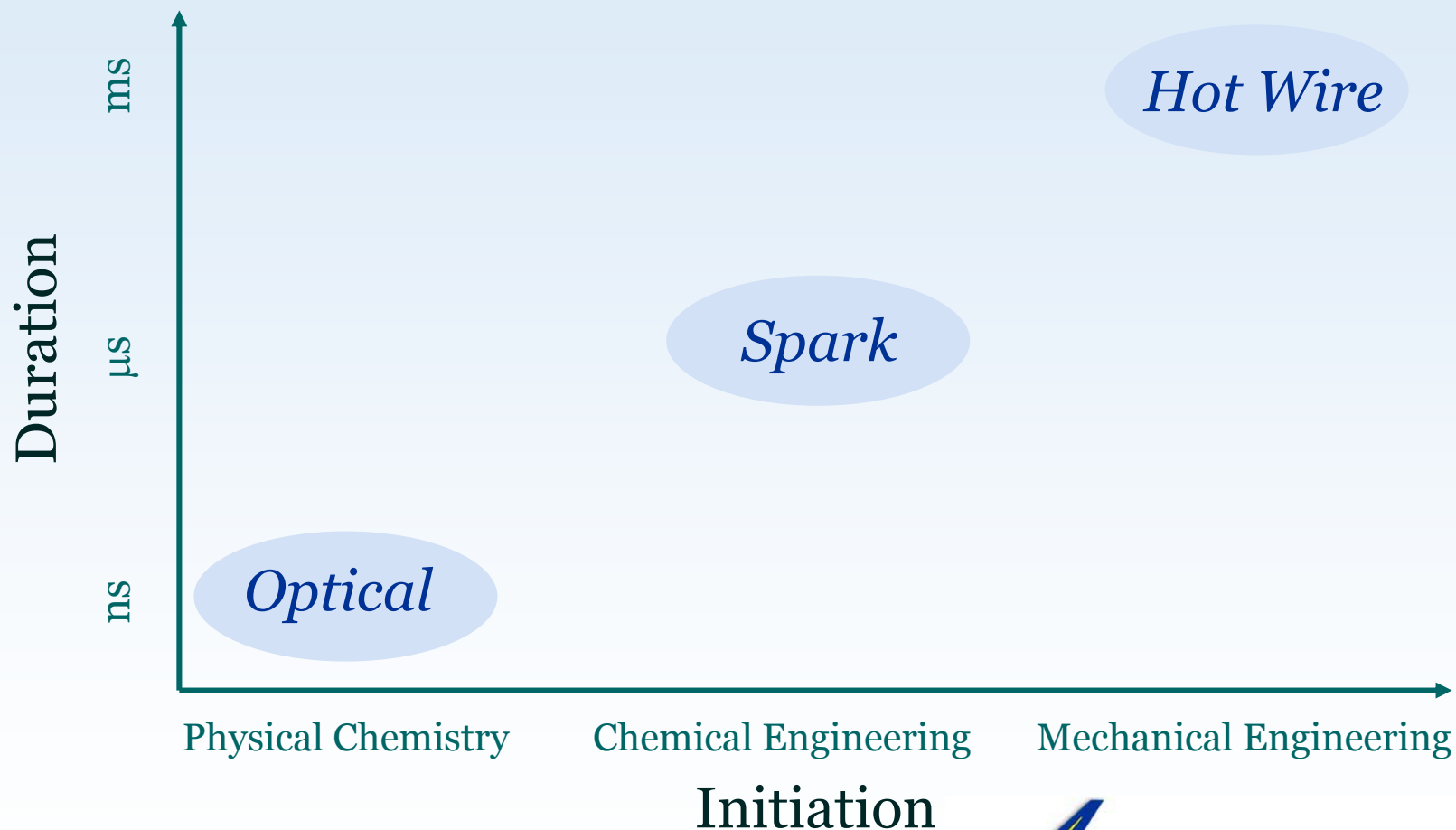
Perhaps there are other concerns.



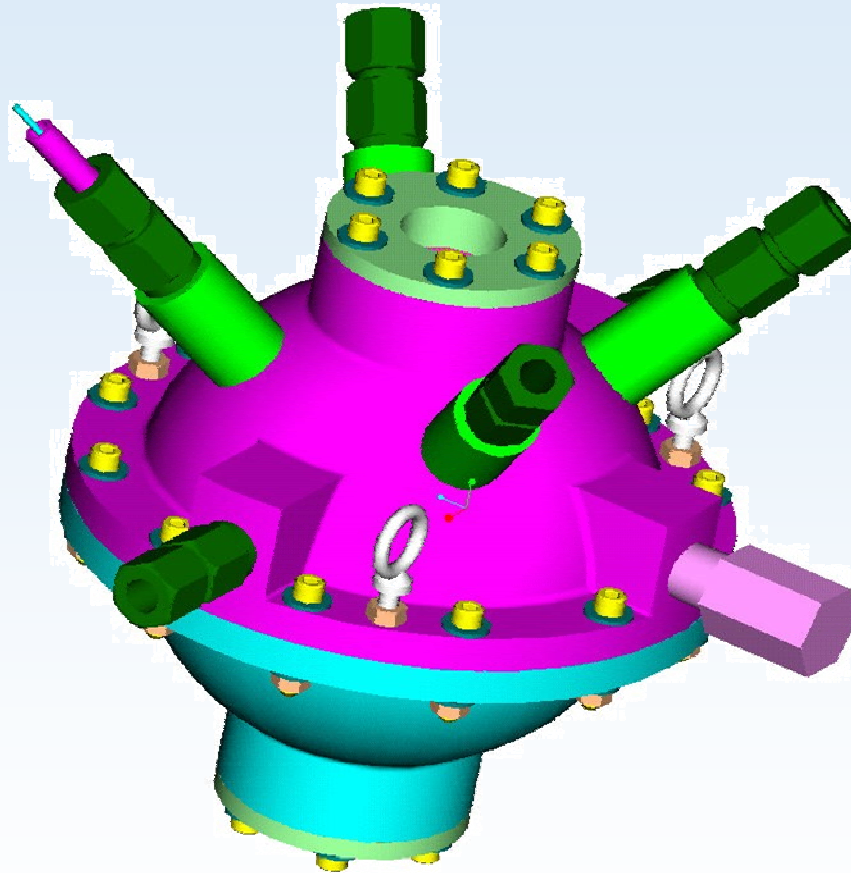
Methanol MIE



Type of Ignition Source



Combustion Vessel



GRC MIE Experimentation Combustion Vessel Apparatus

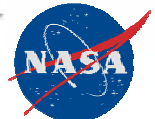


Sparks Move Around



“Dancing” Spark

30 μ s Between Frames

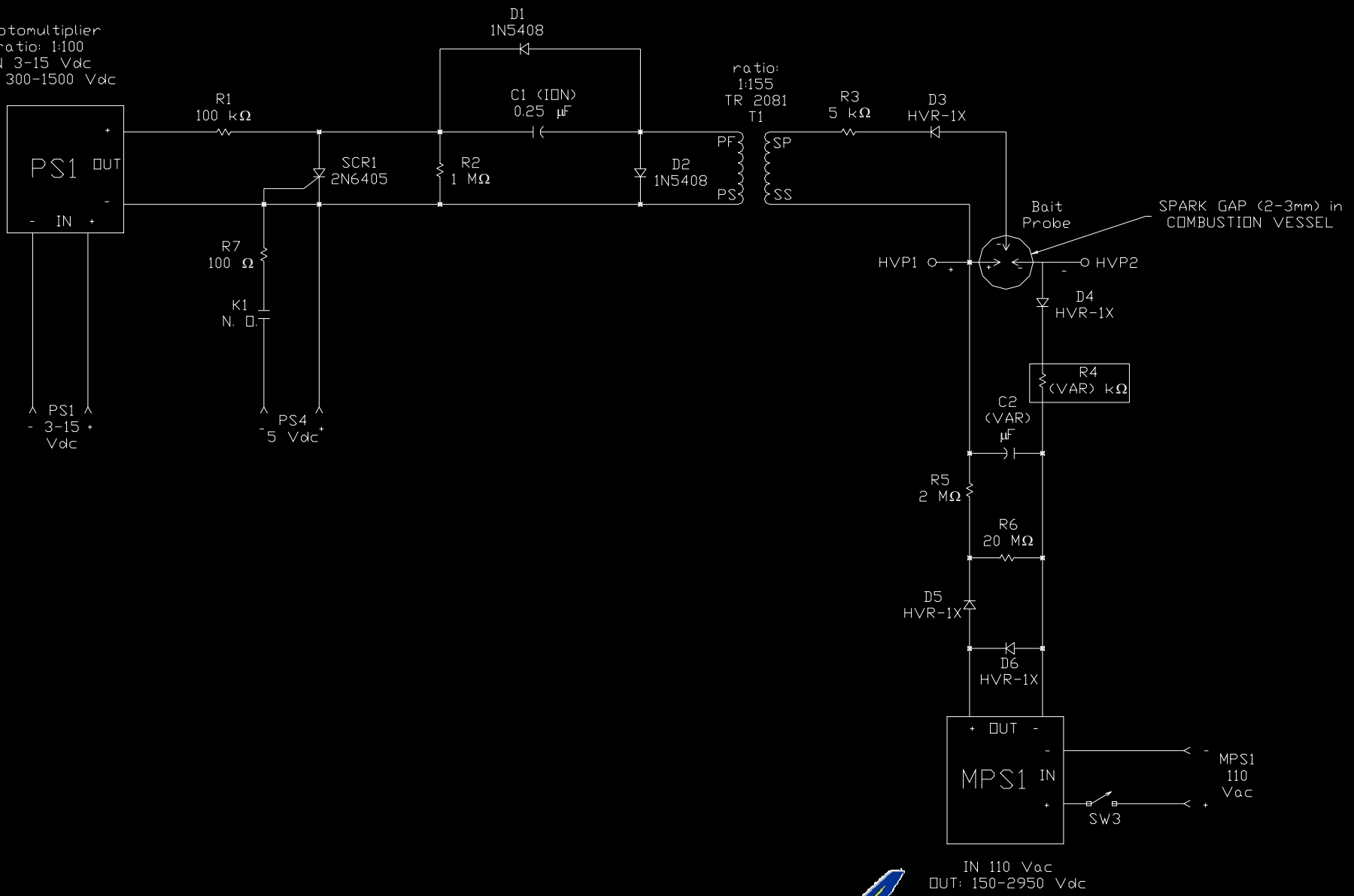


GRC MIE Experimentation

Combustion Vessel Apparatus ~ Internal Configuration

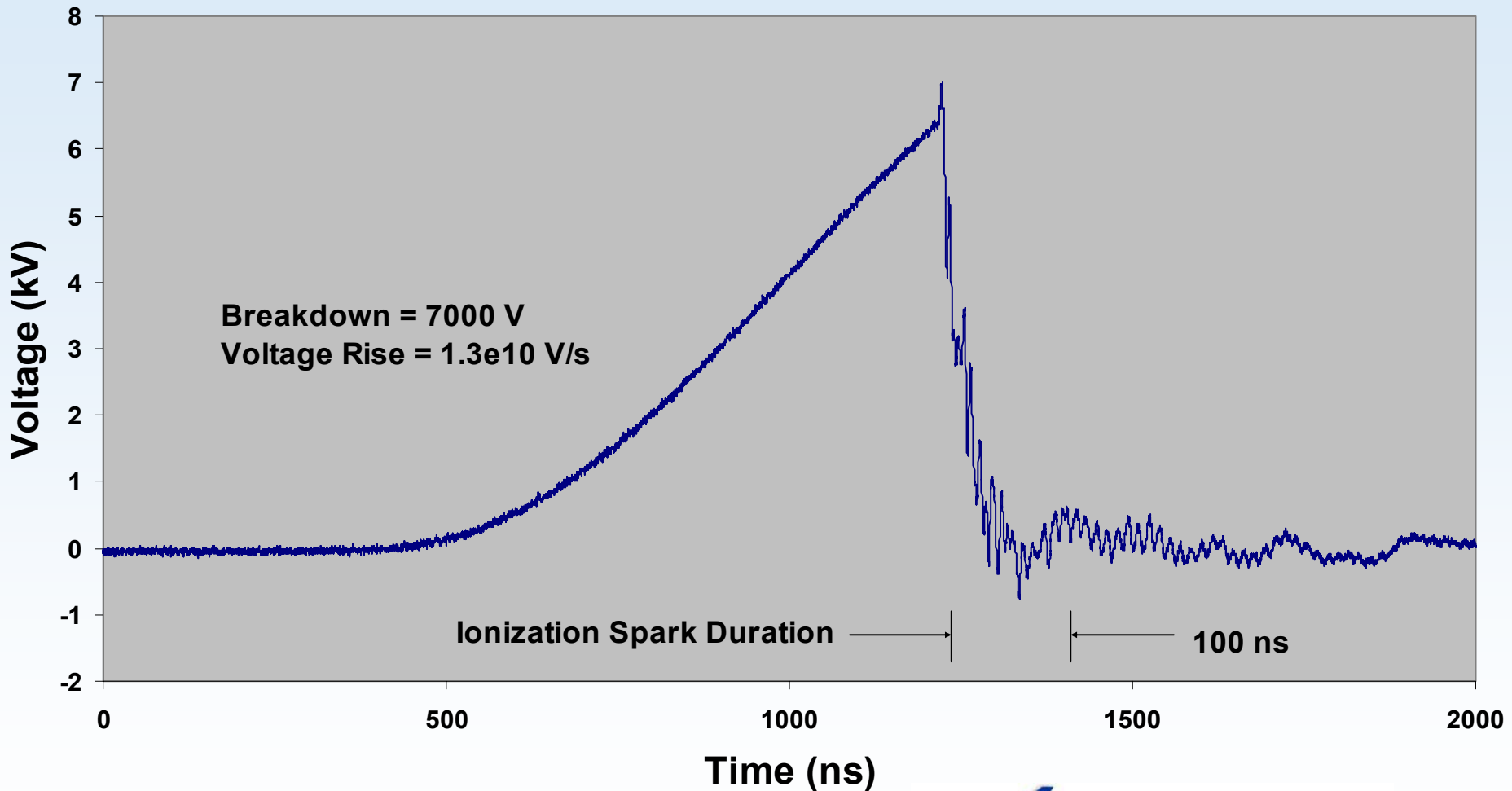


Photomultiplier
 ratio: 1:100
 IN 3-15 Vdc
 OUT: 300-1500 Vdc



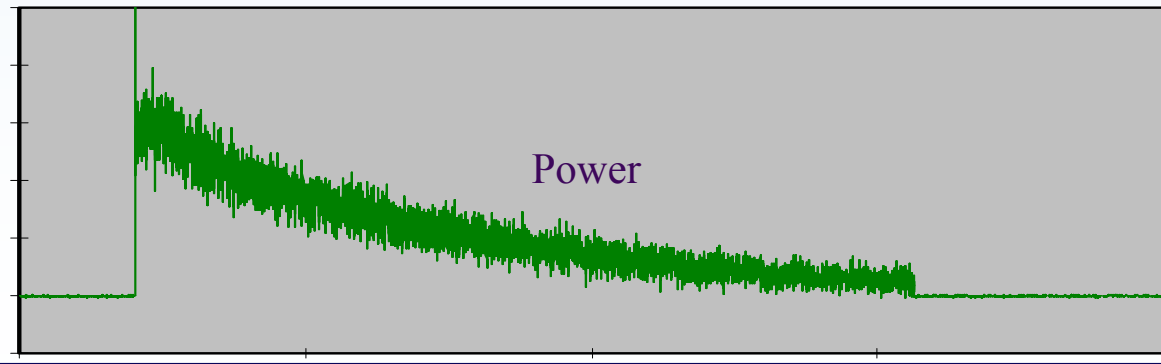
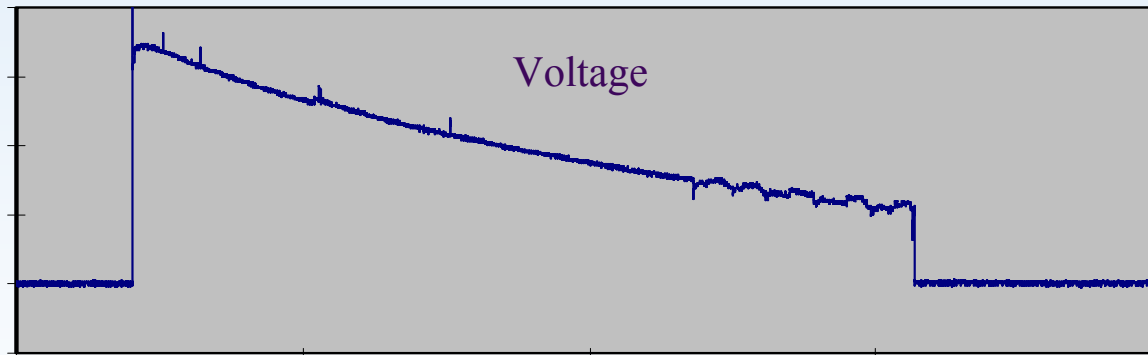
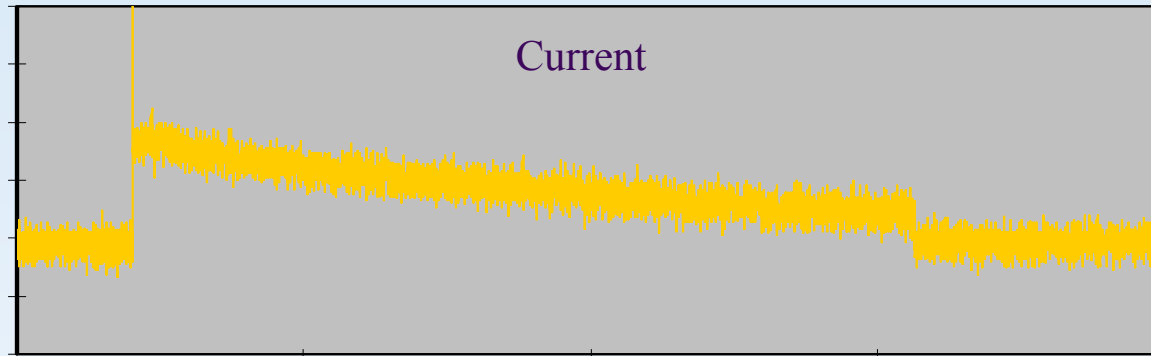
Typical Ionization Profile

70 μ J Spark Energy

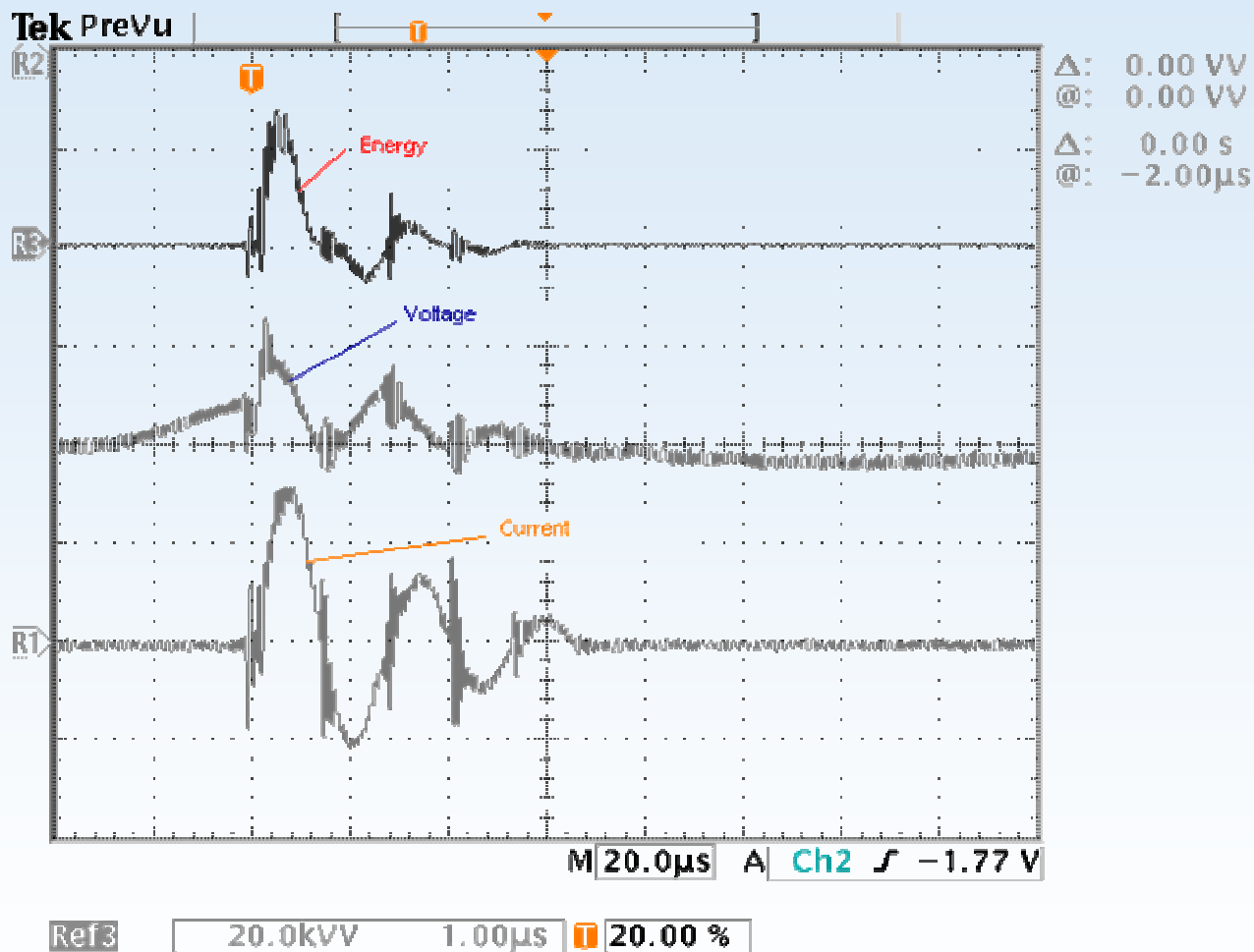


Typical Energy Measurement

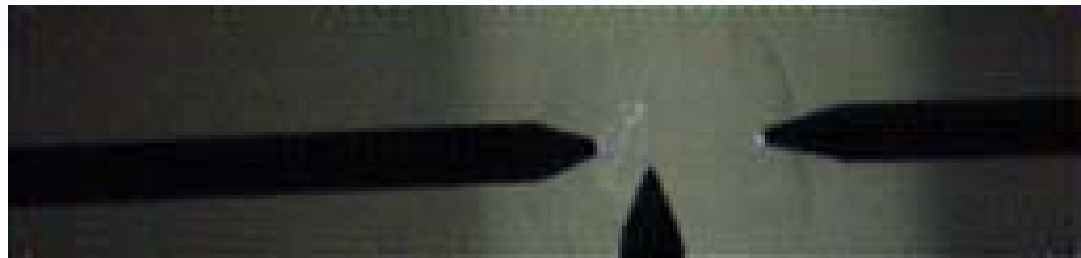
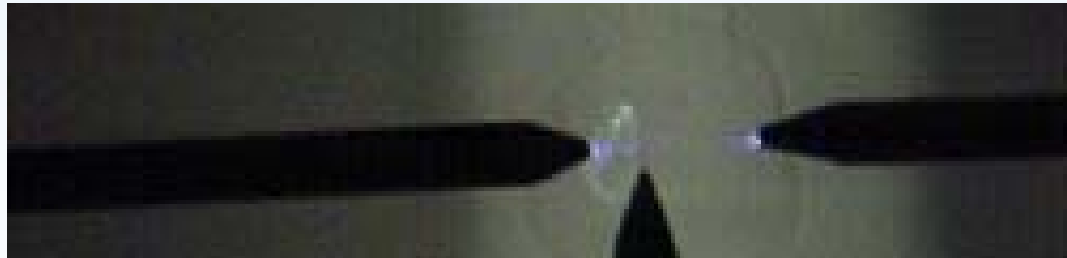
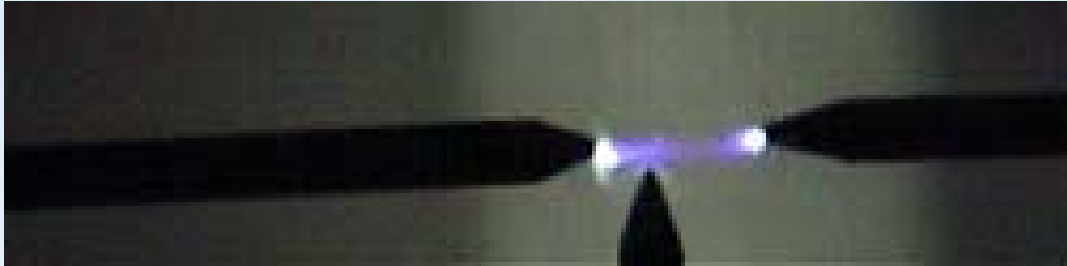
$$\text{Energy} = \int (\text{Voltage} \times \text{Current}) dt$$



Oscillating Sparks



Nice Looking Spark



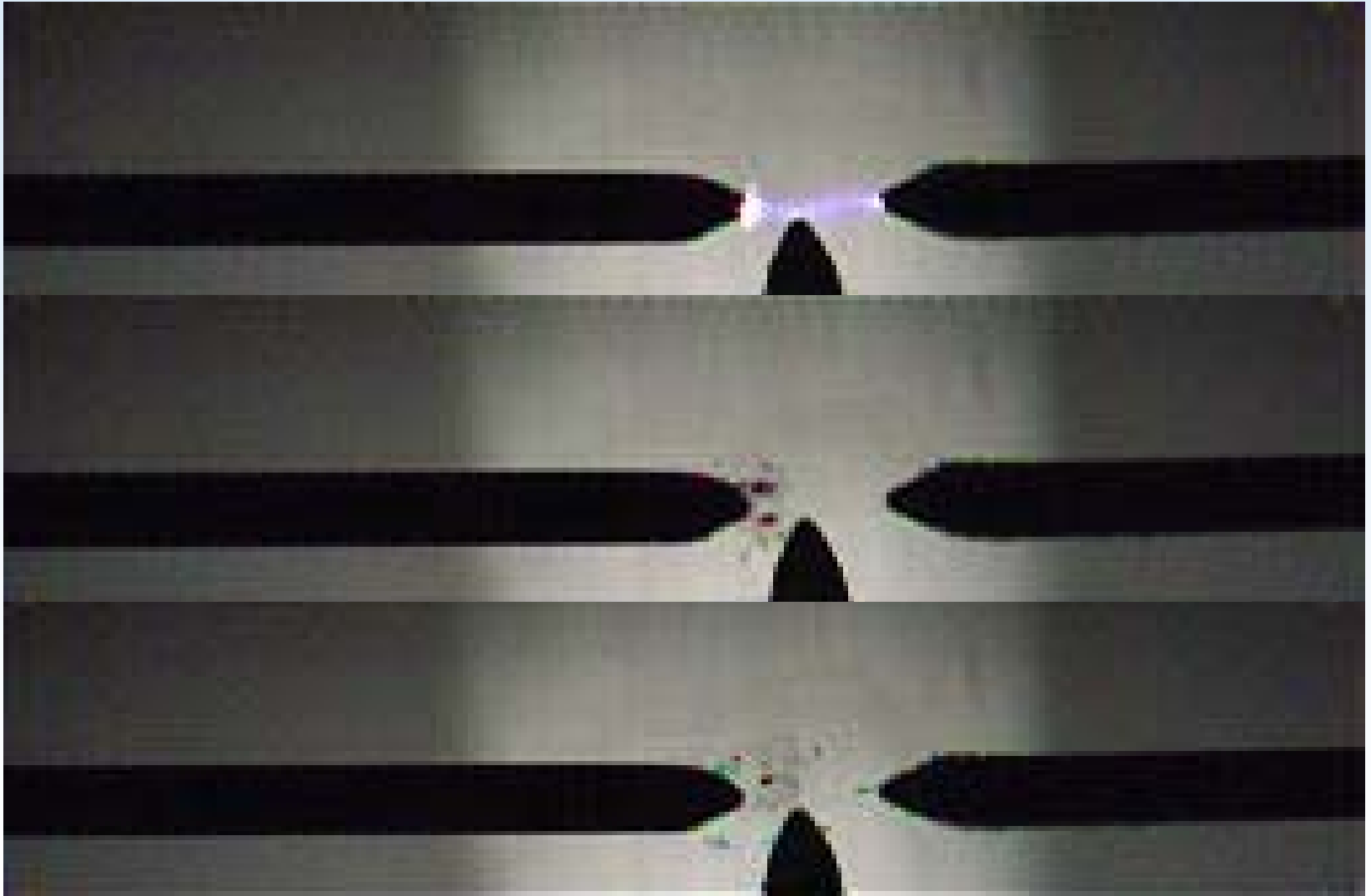
Nice Looking Spark -- Animation



Reaction Wave



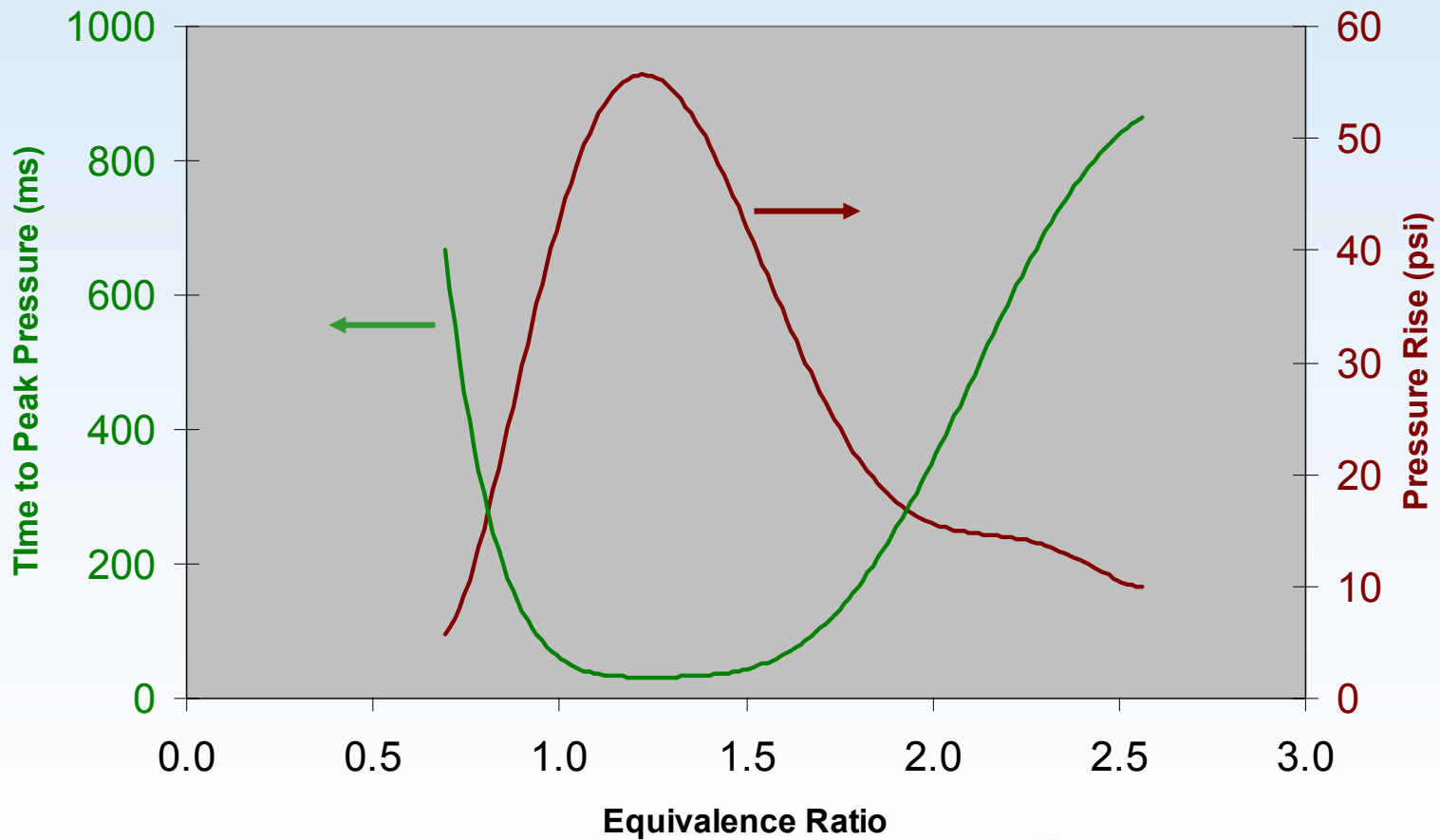
Carbon Build Up



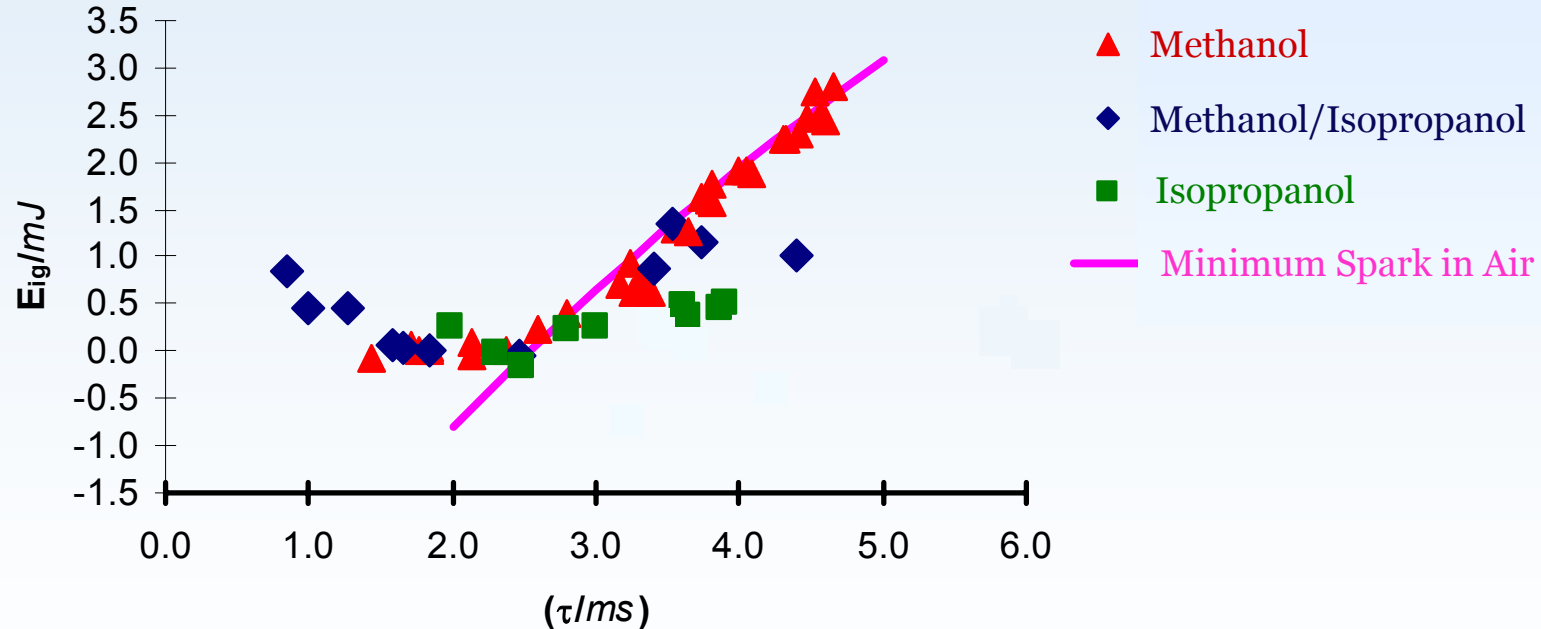
Carbon Build Up --Animation



Methanol

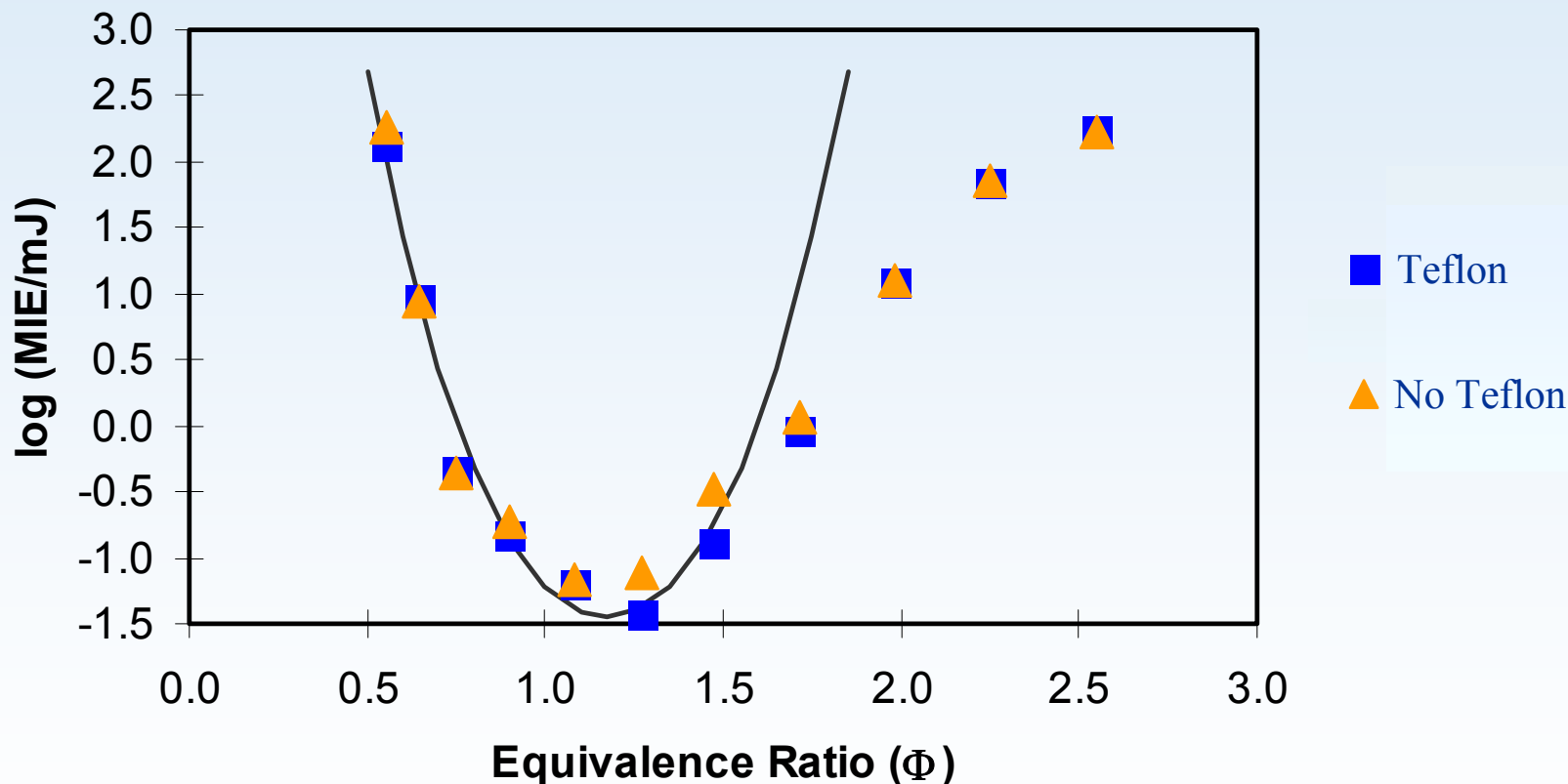


Effect of Vapor Composition on Minimum Ignition

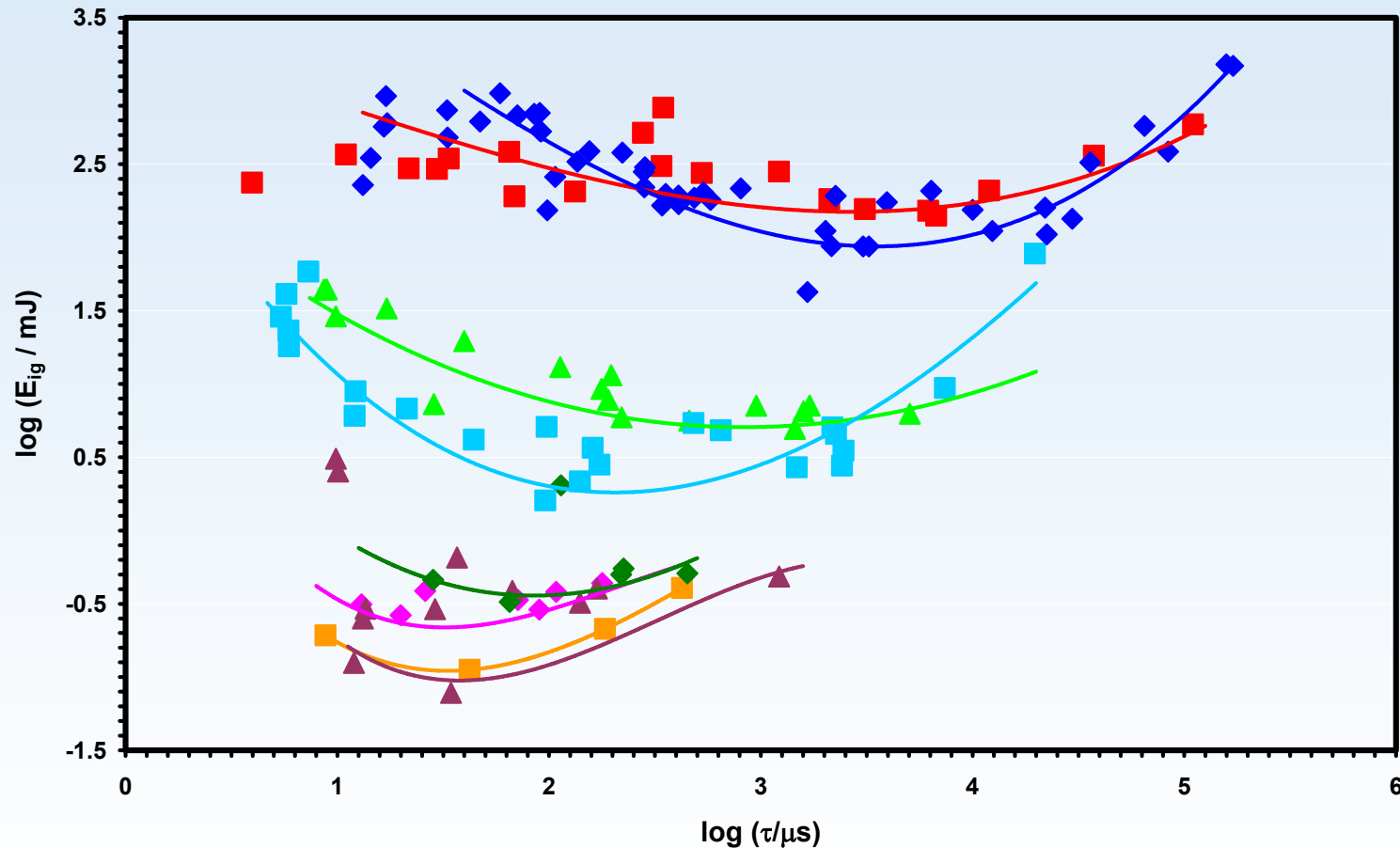


Methanol Minimum Ignition Energy

Effect of Electrical Isolation



Methanol MIE vs Spark Duration

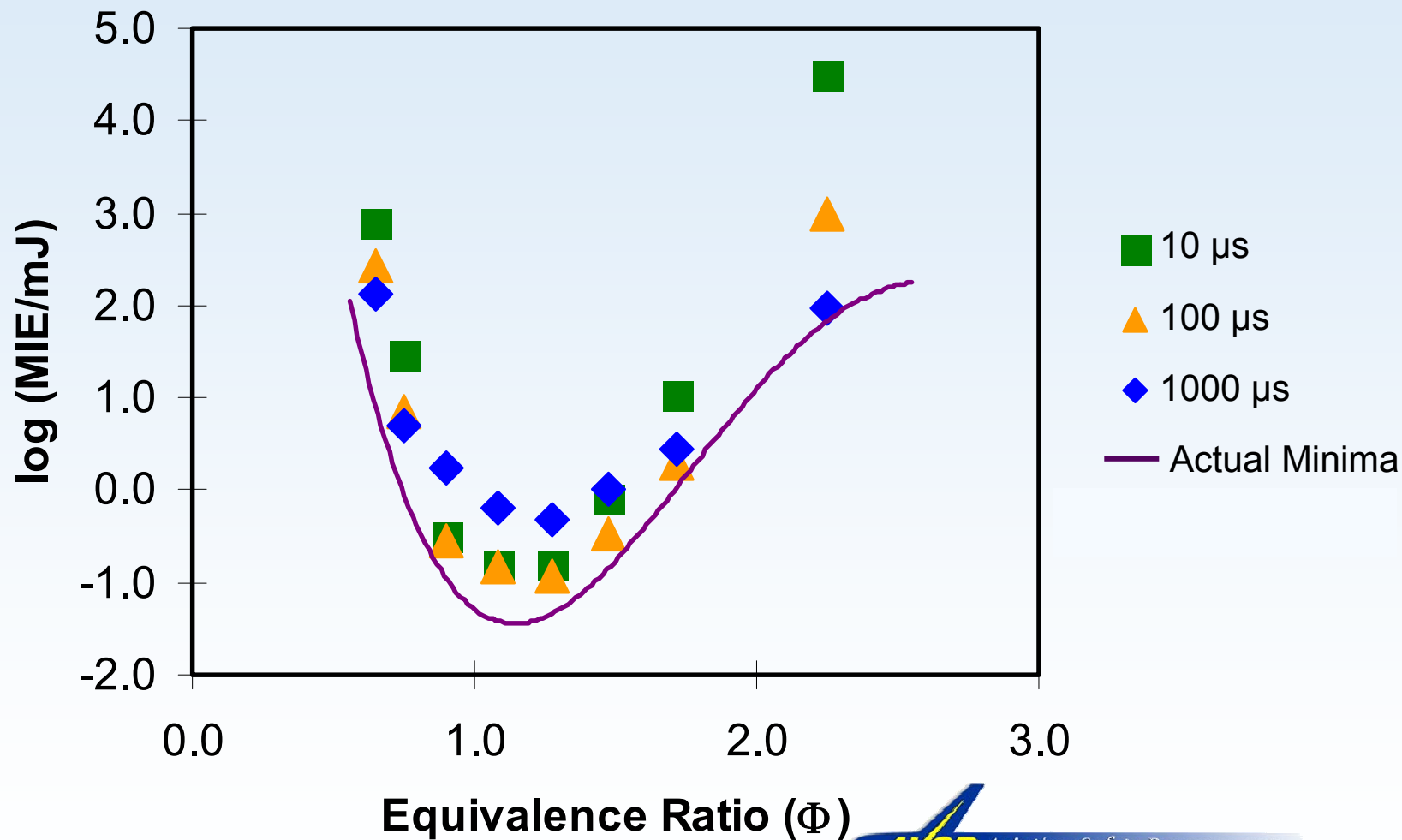


■ — 12.5 °C ▲ — 14.5 °C ◆ — 17.5 °C ■ — 20.0 °C
▲ — 22.5 °C ◆ — 25.0 °C ■ — 27.5 °C ◆ — 32.5 °C



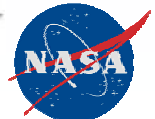
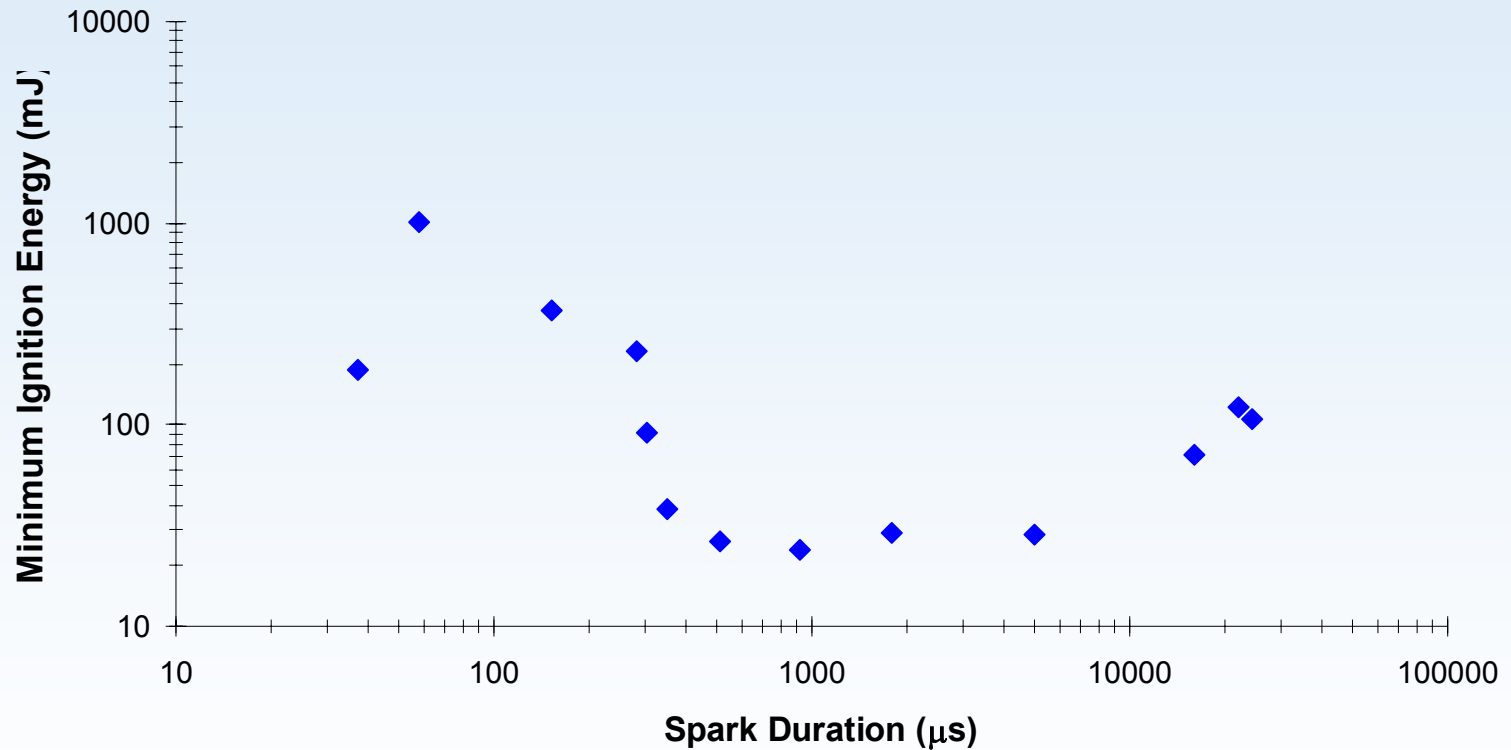
Methanol Minimum Ignition Energy

Effect of Varying Spark Duration



Iso-Octane MIE @ 21°C

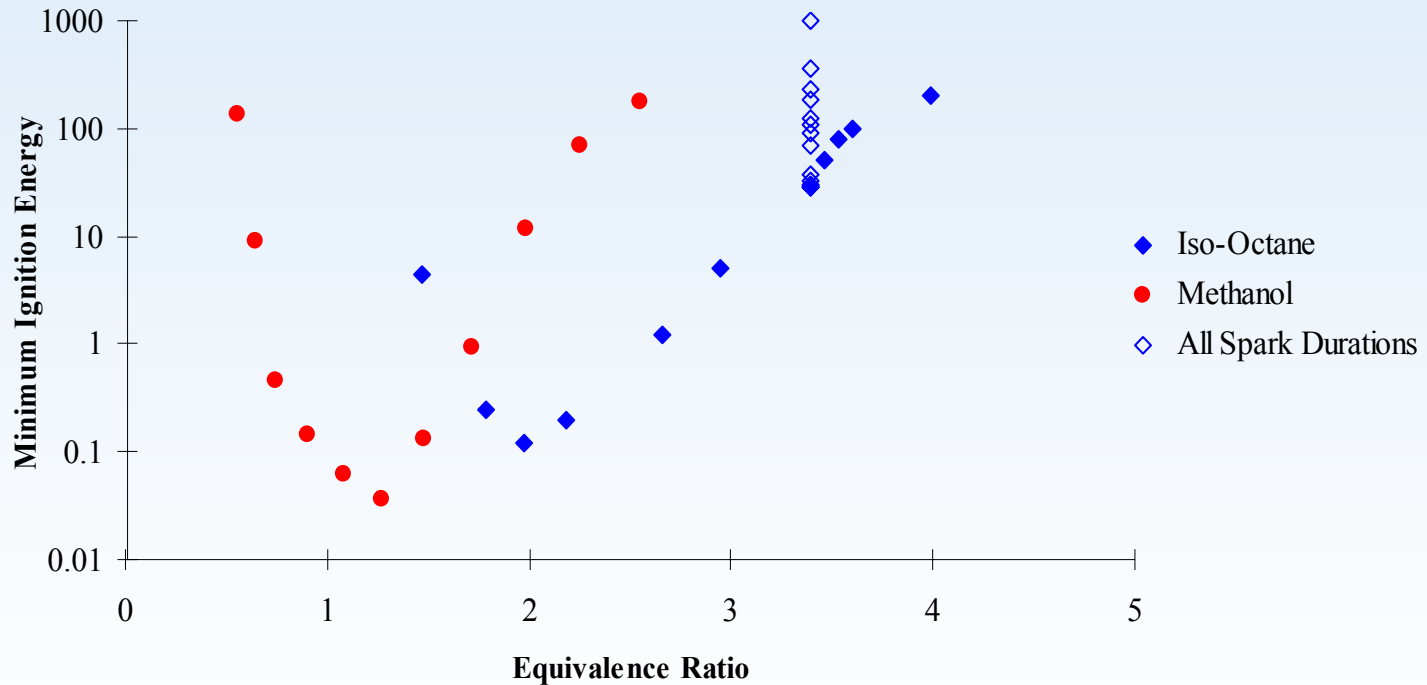
Effect of Varying Spark Duration



More Than Enough Energy



MIE Curves for Methanol and Iso-Octane



Conclusions

MIE Depends Upon Ignition Source and Duration

Shape of MIE vs Temperature Curves Varies Strongly with Spark Properties

Not So Easy – Need To Find Spark Duration for MIE at Each Condition